



# CDR IN OPERATIONS

## A Fundamental Climate Data Record of Intercalibrated Brightness Temperature Data from SSM/I and SSMIS

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CDR Team Meeting  
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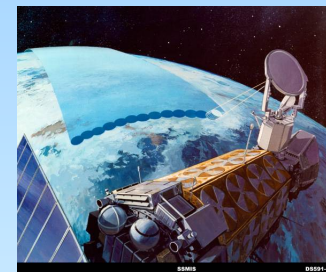
# Project Description

## CSU SSMI(S) FCDR

- Goal: Develop a long-term intercalibrated brightness temperature dataset (i.e. FCDR) from the DMSP window-channel radiometers.
- FCDR Definition: Fundamental Climate Data Records are sensor data that have been improved and quality-controlled over time, together with ancillary data used to calibrate them.
  - The sensor data is physically consistent, but sensor dependent due to differences in frequencies, view angles, resolution, observation time etc.
  - Geophysical retrieval algorithms must take into account sensor differences in order to create TCDR.
  - Feedback from TCDR developers is critical to ensure best possible dataset for a wide variety of applications.

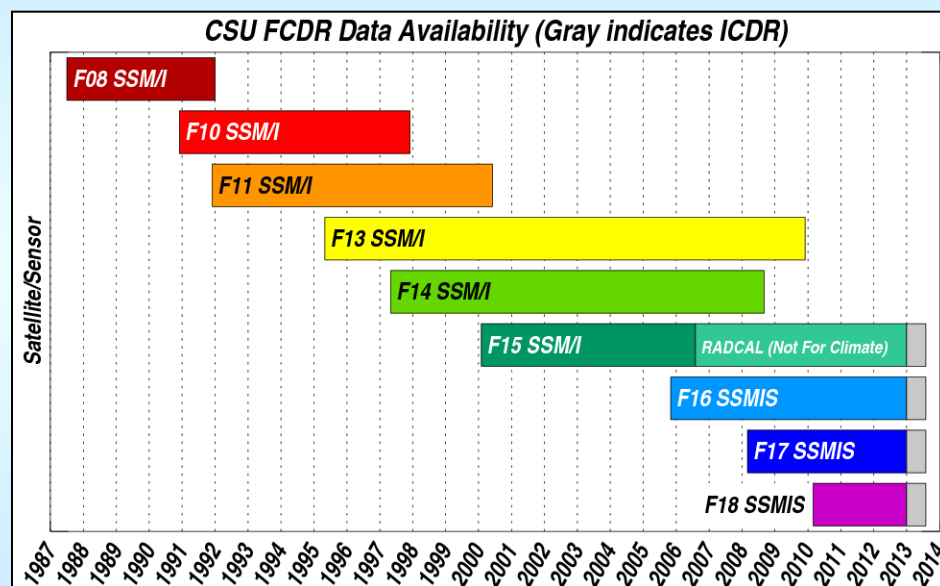


# CSU FCDR Product Description



- SSM/I and SSMIS are polar-orbiting passive microwave radiometers flying aboard DMSP satellites
- 6 SSM/I sensors starting 1987
  - F08, F10, F11, F13, F14 and F15
- 5 SSMIS sensors
  - F16, F17, F18 currently available
  - F19 and F20 not yet launched
- V1 SSM/I and SSMIS FCDR available for period shown in figure on the right.
- V1 Interim Climate Data Record (ICDR) data from Jan 2013
- All sensors are calibrated to SSM/I on board F13
- F15 RADCAL correction applied Aug 2006 forward (deemed not suitable for climate).

SSM/I: Special Sensor Microwave/Imager  
SSMIS: Special Sensor Microwave Imager/Sounder



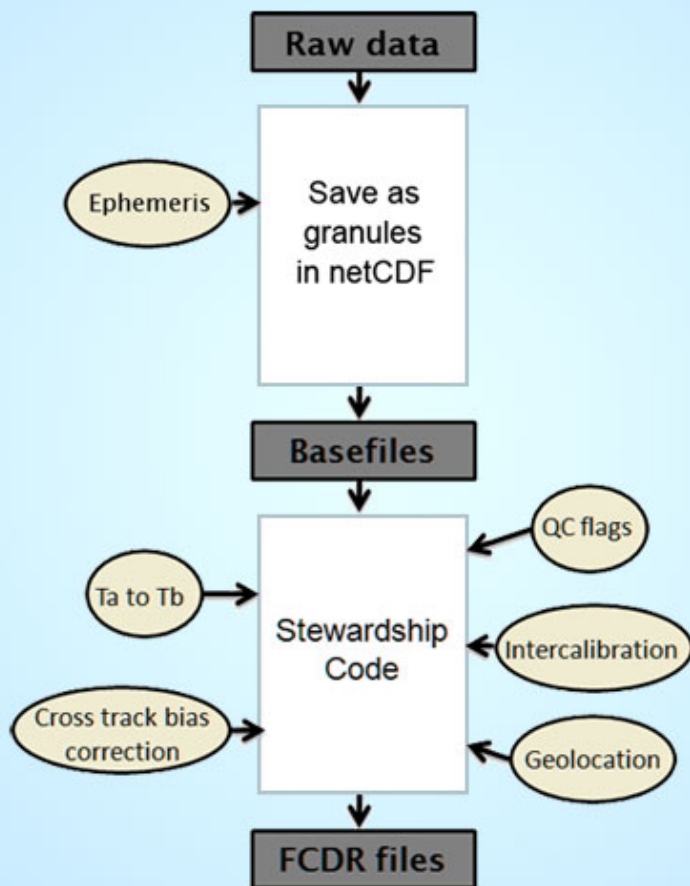
**SSM/I has 7 Channels:**  
19 V&H, 22 V, 37 V&H, 85 V&H GHz

**SSMIS has 24 Channels**  
7 correspond to SSM/I:  
19 V&H, 22 V, 37 V&H, 91 V&H GHz

# CSU FCDR Product Description

## (Approach -> from TDR to FCDR files)

### Data Processing



1. Reformat SSMI/SSMIS TDR files into NetCDF “**Base files**”. These files contain **all** the original data and **nothing is modified** except to make orbit granules, add ephemeris and reformatted time, and reformat to NetCDF.
2. Create a **well documented software** package (“**Stewardship code**”) that ingests the Base files, applies corrections and outputs the final FCDR in NetCDF for use by the broader community. Modules include the following.
  - **Quality control:** (Sets/flags bad data to missing and flags potential problems)
  - **Cross-track bias correction:** (Adjusts for unphysical end-of-scan dropoffs)
  - **Warm/cold load contamination correction:** (Corrects for intrusions into warm/cold loads)
  - **SSMIS sun-angle correction:** (Correction for emissive antenna and heating/intrusion related biases, SSMIS only)
  - **Geolocation:** (Computes pixel geolocation based on attitude adjustments and TLE-based spacecraft ephemeris)
  - **Antenna temperature to brightness temperature:** (Accounts for antenna pattern including sidelobes and cross-pol)
  - **Intercalibration:** (Adjusts for sensor differences for both warm and cold TBs).

# CSU FCDR Product Description

## Dataset Summary

Product	Sensor	Satellites	Start	End	Volume
BASE	SSM/I	F08, F10, F11, F13, F14, F15	July 1987	Present (2-7 day lag)	1310 GB
“	SSMIS	F16, F17, F18	Nov 2005	Present (2-7 day lag)	1700 GB
FCDR	SSM/I	F08, F10, F11, F13, F14, F15	July 1987	Dec 2012	1580 GB
“	SSMIS	F16, F17, F18	Nov 2005	Dec 2013	1830 GB
ICDR	SSM/I	F15	Jan 2013	Present (2-7 day lag)	16 GB
“	SSMIS	F16, F17, F18	Jan 2013	Present (2-7 day lag)	210 GB

# Product Delivery Description

CDR(s)	Period of Record	Temporal Resolution	Update Frequency	Update Lag	Spatial Resolution	Data file distinction criteria	Do you publicly serve the CDR at your institution?
SSM/I and SSMIS FCDR (F08, F10, F11, F13, F14, F15, F16, F17, and F18)	July 1987 through present	Variable depending on number of concurrent satellites (0-2 obs/day for each satellite)	Daily for BASE files and ICDR files. FCDR data updated only every 6-12 months	2-7 days	15-50km depending on channel frequency	Files are defined by orbit and satellite	Yes. Summary of ftp logs delivered to NCDC quarterly.

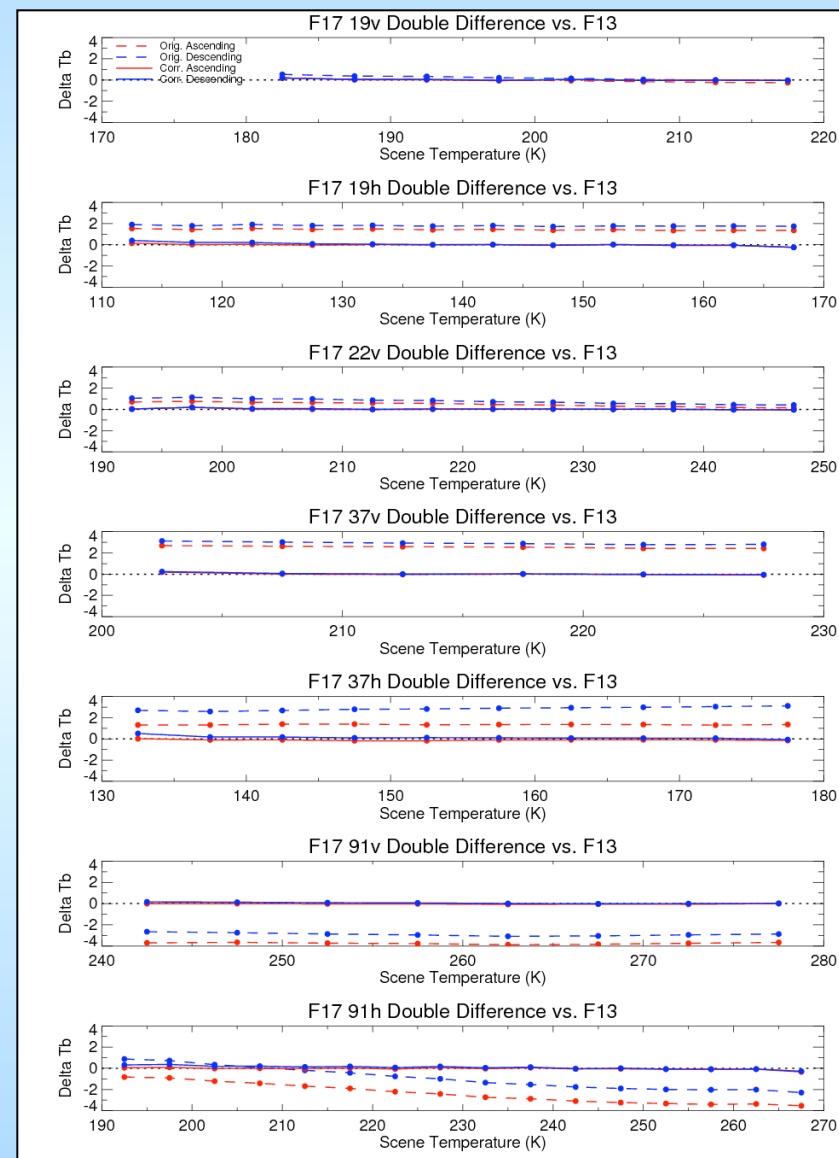
- BASE Files -> NetCDF files containing raw data from input TDR files.

# Validation & Quality Assurance

1. Analysis of time series of geophysical ocean retrievals
    - Application and analysis for entire FCDR data record (9 sensors).
    - Optimal estimation retrieval for non-precipitating ocean scenes (i.e. TPW, CLWP, and surface wind speed).
    - Latest GPROF 2010 precipitation algorithm
  2. Assessment by PMM XCAL team
    - Collaboration with PMM XCAL team to assess quality of data/intercalibration.
  3. Monitoring of input SSMIS TDR data
    - Daily averaged warm and cold counts, gain, calibration slope, Nedt, and antenna temperatures.
    - Comparisons versus long-term averages.
    - Available online at <http://rain.atmos.colostate.edu/FCDR>.
- Product quality Assessment for each update period (6-12 months)
    - Same as items 1-3 above

# Validation & Quality Assurance

1. Visual inspections and verification of the various corrections applied to the data. See example of decrease in bias between ascending and descending passes in figure on the left for SSMIS on board F17.
2. Implementation of multiple intercalibration approaches to check for consistency between independent techniques and to provide estimate of residual calibration uncertainties.
3. Application to geophysical retrievals. Working with thematic CDR or TCDR developers and applying in-house retrievals including (currently) a non-precipitating ocean retrieval of TPW, CLWP, and surface wind speed, and the latest operational GPROF precipitation retrieval.
4. A comparison of GPROF rainfall estimates based on coincident overpasses with TRMM TMI indicates mean rainfall differences between the SSMIS sensors and with TMI of less than 3%. Agreement between the SSMIS sensors and TMI is slightly better with differences of less than 1%. The sun angle and associated heating issues are a significant issue for the SSMIS sensors and most problematic for F17 and best for F18.
5. Comparisons with independent FCDRs including the RSS V7 FCDR for F17 when available. We are also working with members of the GPM XCAL team and researchers at the CM-SAF in their development of an SSMIS FCDR to identify problems and improve upon existing corrections etc.



# Concerns, Risks and Issues

- Algorithm or product errors/issues
  - Warm scene calibration for SSMIS sensors (i.e. land).
    - Current approaches are mostly based on ocean-based cold scene comparisons. For some channels calibration changes significantly with scene temperature.
  - We are currently working with researchers at the University of Central Florida to estimate biases and associated uncertainties using a warm scene intercalibration approach over the Amazon.
- Technical risks/issues that may jeopardize sustained provision of the FCDR/ICDRs
  - Availability of TLE files for near real-time processing
    - We currently get TLE files via NASA, but delays and missing days occur frequently and there is no guarantees that this source won't get cut off.
    - We have determined that we can use predicted ephemeris from TLE up to a week with very minimal impact to the pixel geolocation (i.e. within current error tolerances).
  - Mitigation plan: We would like to identify/procure a reliable source within NOAA to obtain TLE files.

# Uses & Applications

## ■ Applications and Uses

- Given that this is an FCDR of brightness temperatures, the primary application is for algorithm developers wishing to produce TCDRs.
- We are currently working with a number of TCDR developers including the Global Precipitation Climatology Project (GPCP), SeaFLUX, and researchers at NSIDC developing sea-ice products.
- We are also working with the XCAL intercalibration working group for the Global Precipitation Mission and Eumetsat's Climate Monitoring Satellite Applications Facility to identify issues/problems, make improvements, and better determine the residual uncertainties.

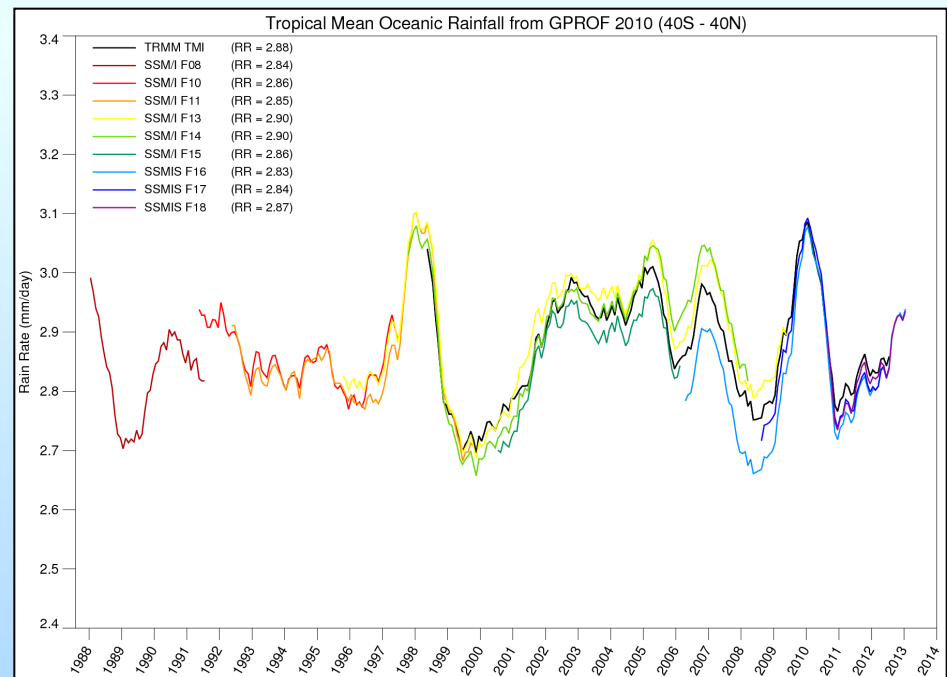
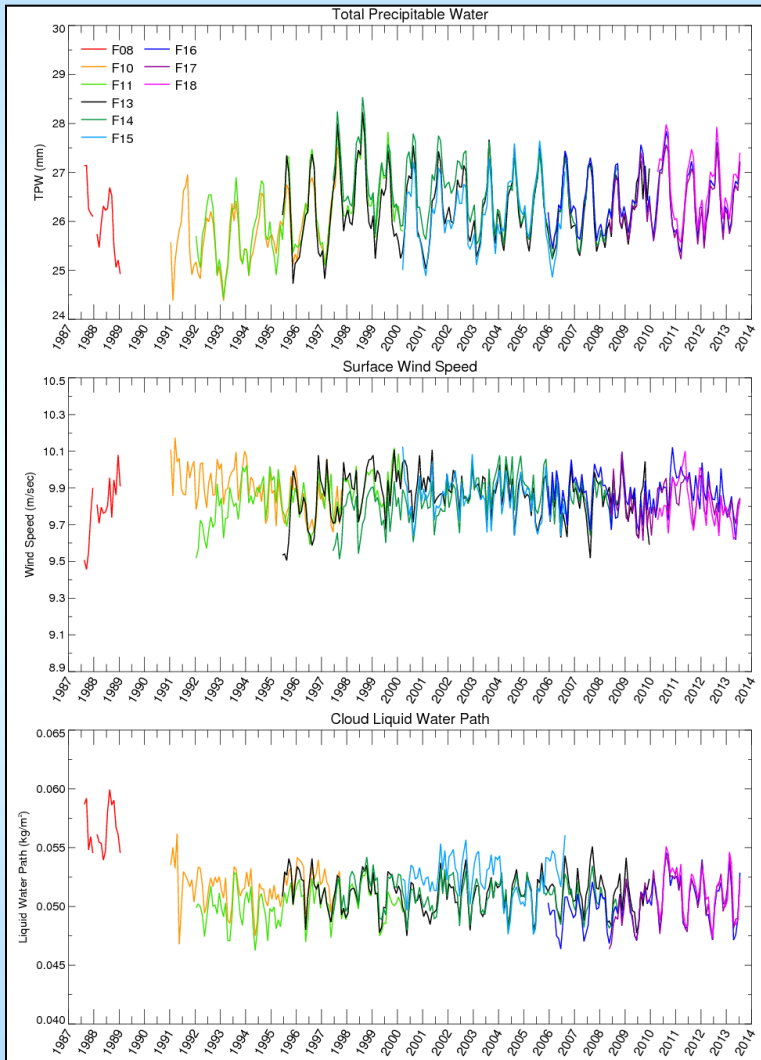
## ■ Key Scientific Findings

- The application of the latest operational GPROF precipitation retrieval algorithm to the SSMI(S) FCDR shows no discernable trend in tropical oceanic precip over the 25+ year extent of the current data record. This appears quite consistent with the TRMM TMI results over its more limited 15+ year extent.

# Uses & Applications

## Time Series of Geophysical Retrievals

- Geophysical time series from all nine SSM/I and SSMIS sensors in the CSU FCDR.
- Figure on the left shows the time series of total precipitable water, surface wind speed and cloud liquid water for non-precipitating ocean scenes
- Figure below shows the time series of oceanic precipitation from the FCDR plus TRMM TMI based on the latest GPROF retrieval algorithm.



# Schedule

## (Data Archive and Near Real-Time Updates)

### ■ BASE Files

- Produced for F08, F10, F11, F13, F14, F15, F16, F17 and F18
- Updated daily in near real-time for F15, F16, F17, and F18
- Available from NOAA HDSS Access System

### ■ FCDR status

- Produced for F08, F10, F11, F13, F14, F15, F16, F17 and F18
- Completed and delivered to NCDC through December 2012
- Updates planned every 6-12 months
- Available from CSU ftp server and NOAA HDSS Access System

### ■ ICDR status

- Near real-time ICDR (i.e. interim climate data record) files updated daily for F15, F16, F17, and F18 (2-7 day lag).
- Available from CSU ftp server and NOAA HDSS Access System

# Schedule (Future)

- 1-3 Year Planning Horizon
  - Data production:
    - Continue production of ICDR files from F15, F16, F17, and F18
    - Investigate data from F19 after launch (scheduled for 2014). Work to incorporate into FCDR record.
  - FCDR Improvements:
    - Investigate warm-scene (i.e.) land calibration using Amazon or other warm targets
    - Revisit cross-track bias correction
  - Collaboration:
    - Continue to work with PMM XCAL and CM-SAF to identify issues and improve existing FCDR data record.
    - Continue to work with TCDR developers.
- Requests/Recommendations for the CDR Program
  - Assistance in obtaining reliable source for TLE data.

# Documentation

<http://rain.atmos.colostate.edu/FCDR>

The screenshot shows the FCDR website with a navigation bar at the top containing links like Weather, News, Misc, Calendar, Woodworking, Skiing, Cycling, Silverton, Photo, Financial, CSU, and Bookmarks. The main content area is divided into three columns: Overview, SSM/I, and SSMIS. The Overview column includes sections for Overview, Motivation, Data Availability, Approach, and Validation. The SSM/I column includes sections for Description, Geolocation, Inter-calibration, Data, and Software. The SSMIS column includes sections for Description, Geolocation, Inter-calibration, Data, Software, and Documentation. A small chart titled 'CSU FCDR Data Availability (long indicates FCDR)' is visible in the Overview section.

**Overview**

**Overview:** The definition, goals, and anticipated user communities

**Motivation:** Why having a transparent, well-documented process is as important as producing an intercalibrated dataset

**Data Availability:** The time range of currently available data from all of the SSM/I and SSMIS sensors

**Approach:** A description of the intercalibration methods and data processing flow

- [Intercalibration](#)
- [Data Processing Flow](#)
- [Baselines](#)
- [Stewardship Code](#)
- [FCDR Files](#)

**Validation:** Time series of geophysical products

**SSM/I**

**Description:** Specifications for the Special Sensor Microwave/Imager and DMSP spacecraft

**Geolocation:** Description of the motivation, methodology and results from an analysis of the pixel latitude/longitude

**Inter-calibration:** Detailed explanation of multiple approaches to sensor intercalibration along with results

**Data:** Information on availability, format specifications, and data access

- [Get FCDR Data](#)
- [Data Availability](#)
- [Format Specifications](#)

**Software:** Code to read the FCDR files in Fortran, C, IDL and Matlab, along with information on netCDF 4

**Documentation:** Detailed documentation of the CSU FCDR along with a digital archive of reports, journal articles and other information from external sources

**SSMIS**

**Description:** Specifications for the Special Sensor Microwave Imager/Sounder and DMSP spacecraft

**Geolocation:** Description of the motivation, methodology and results from an analysis of the pixel latitude/longitude

**Inter-calibration:** Detailed explanation of multiple approaches to sensor intercalibration along with results

**Data:** Information on availability, format specifications, and data access

- [Get FCDR Data](#)
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**Software:** Code to read the FCDR files in Fortran, C, IDL and Matlab, along with information on netCDF 4

**Documentation:** Detailed documentation of the CSU FCDR along with a digital archive of reports, journal articles and other information from external sources

**Monitoring:** Monitoring of input near real-time calibration and antenna temperatures data

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## • Goals

1. Preserve existing record of satellite/sensor characteristics, known issues, cal/val activities etc. (Critical before information on early sensors is lost!)
2. Provide sufficient documentation for transfer of FCDR processing to NCDC and for adapting processing code and techniques to future sensors
3. Allow for future developments/improvements to FCDR processing through the use of well documented modular procedures.

## • Currently Available (via website)

1. C-ATBDs for SSM/I and SSMIS, 6 detailed technical reports, 2 journal pubs.
2. Digital archive of all available documentation related to SSM/I and SSMIS sensors.
3. Data format specifications
4. Software to read NetCDF4 FCDR files (Fortran 90, C, IDL, and Matlab)
5. Detailed info on data availability and monitoring of SSMIS input TDR data updated daily along with ICDR data.

# Summary

- Critical issues for construction of SSMI/SSMIS FCDR
  - Quality Control
  - Accurate estimation of EIA for each pixel
  - Intercalibration between sensors
- Version 1 of SSM/I and SSMIS FCDR released. Available from both CSU ftp and NOAA HDSS Access System.
- Application of geophysical ocean retrievals shows good consistency between sensors. Also indicates no discernable trend in tropical ocean precip over 25+ year data record.
- Near real-time updates of BASE files and ICDR data from F15, F16, F17 and F18.
- We will continue to work with other developers and intercalibration efforts (i.e. XCAL, CM-SAF) as well as TCDR developers to solicit feedback.